

WHAT IS CLAIMED IS:

1. A semiconductor device manufacturing method comprising the steps of:

forming a gate insulating film in an oxynitride form on a main surface of a semiconductor substrate; forming gate electrodes on the gate insulating film;

forming impurity diffused layers on both sides of the respective gate electrodes in the semiconductor substrate; and

removing part of the gate insulating film which lies on the impurity diffused layers.

2. The semiconductor device manufacturing method according to claim 1, wherein said step of forming the gate insulating film includes steps of thermally oxidizing the main surface of the semiconductor substrate to form an oxide film, nitrifying the oxide film, and oxidizing the nitrified oxide film again.

3. The semiconductor device manufacturing method according to claim 1, wherein said step of removing part of the gate insulating film which lies on the impurity diffused layers is effected by using at least one of hot phosphoric acid, a mixed solution of hydrofluoric acid and glycerol, a mixed solution of hydrofluoric acid and ethylene glycol, a mixed solution of hydrofluoric acid and ethylene glycol mono-ethyl ether and hydrofluoric acid vapor.

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4. The semiconductor device manufacturing method according to claim 1, wherein said step of removing part of the gate insulating film which lies on the impurity diffused layers is effected by use of an isotropic etching process.

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5. The semiconductor device manufacturing method according to claim 1, further comprising a step of forming an insulating film on the impurity diffused layers after said step of removing part of the gate insulating film which lies on the impurity diffused layers is effected.

6. The semiconductor device manufacturing method according to claim 5, wherein said step of forming an insulating film on the impurity diffused layers is forming a post oxidation film effected by use of thermal oxidation method.

7. The semiconductor device manufacturing method according to claim 6, further comprising a step of nitrifying the post oxidation film.

8. The semiconductor device manufacturing method according to claim 5, wherein said step of forming an insulating film on the impurity diffused layers is forming an oxidation film effected by using at least one of vaporizer method, an oxyhydrogen combustion method and wet oxidation method.

9. The semiconductor device manufacturing method according to claim 1, further comprising a step of

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forming an oxynitride film on the impurity diffused layers after said step of removing part of the gate insulating film which lies on the impurity diffused layers is effected.

5 10. A semiconductor device manufacturing method comprising the steps of:

forming a gate insulating film in an oxynitride form on a main surface of a semiconductor substrate;

10 forming gate electrodes on the gate insulating film;

forming impurity diffused layers on both sides of the respective gate electrodes in the semiconductor substrate; and

15 making nitrogen concentration of part of the gate insulating film which lies on the impurity diffused layers lower than nitrogen concentration of part of the gate insulating film which lies under the gate electrodes by oxidizing the gate electrodes and impurity diffused layers at temperatures not lower than  
20 950°C.

11. The semiconductor device manufacturing method according to claim 10, wherein said step of lowering the nitrogen concentration of part of the gate insulating film which lies on the impurity diffused layers is effected by use of a wet oxidation method.

25 12. A semiconductor device manufacturing method comprising the steps of:

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forming a gate insulating film in an oxynitride form on a main surface of a semiconductor substrate; forming gate electrodes on the gate insulating film;

5 forming impurity diffused layers on both sides of the respective gate electrodes in the semiconductor substrate;

forming a post oxidation film on the impurity diffused layers; and

10 oxynitrifying the post oxidation film.

13. A semiconductor device manufacturing method comprising the steps of:

forming a first insulating film in an oxynitride form on a main surface of a semiconductor substrate;

15 forming a first conductive layer on the first insulating film;

forming a second insulating film on the first conductive layer;

20 forming a second conductive layer on the second insulating film;

forming a third insulating film on the second conductive layer;

patterning the third insulating film to form a mask;

25 etching the second conductive layer, second insulating film and first conductive layer with the third insulating film used as a mask to form stacked

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gate structures each having a control gate, second gate insulating film and floating gate;

removing part of the first insulating film which lies on the main surface of the semiconductor substrate and is disposed between the stacked gate structures to expose the main surface of the semiconductor substrate and leave another part of the first insulating film which lies under the stacked gate structures, each part of the first insulating film which is left behind under the stacked gate structures acting as a first gate insulating film;

forming a fourth insulating film on side walls and upper surfaces of the stacked gate structures and the exposed main surface of the semiconductor substrate; and

doping impurity into the main surface of the semiconductor substrate with the stacked gate structures used as a mask to form source and drain regions.

14. The semiconductor device manufacturing method according to claim 13, wherein said step of forming the first insulating film includes steps of thermally oxidizing the main surface of the semiconductor substrate to form an oxide film, nitrifying the oxide film, and oxidizing the nitrified oxide film again.

15. The semiconductor device manufacturing method according to claim 13, wherein said step of removing

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part of the first insulating film is effected by using at least one of hot phosphoric acid, a mixed solution of hydrofluoric acid and glycerol, a mixed solution of hydrofluoric acid and ethylene glycol, a mixed solution of hydrofluoric acid and ethylene glycol mono-ethyl ether and hydrofluoric acid vapor.

16. The semiconductor device manufacturing method according to claim 13, wherein said step of removing part of the first insulating film which is effected by use of an isotropic etching process.

17. The semiconductor device manufacturing method according to claim 13, wherein said step of forming the fourth insulating film includes a step of forming oxide films on the side walls and upper surfaces of the stacked gate structures and the exposed main surface of the semiconductor substrate by use of a thermal oxidation method.

18. The semiconductor device manufacturing method according to claim 13, wherein said step of forming the fourth insulating film includes steps of forming oxide films on the side walls and upper surfaces of the stacked gate structures and the exposed main surface of the semiconductor substrate by use of a thermal oxidation method, nitrifying the oxide film, and oxidizing the nitrified oxide film again.

19. The semiconductor device manufacturing method according to claim 13, wherein said step of forming the

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fourth insulating film includes a step of forming oxide films on the side walls and upper surfaces of the stacked gate structures and the exposed main surface of the semiconductor substrate by using at least one of vaporizer method, an oxyhydrogen combustion method and wet oxidation method.

20. A semiconductor device manufacturing method comprising the steps of:

forming a first insulating film in an oxynitride form on a main surface of a semiconductor substrate;

forming a first conductive layer on the first insulating film;

forming a second insulating film on the first conductive layer;

forming a second conductive layer on the second insulating film;

forming a third insulating film on the second conductive layer;

patterning the third insulating film to form a mask;

etching the second conductive layer, second insulating film and first conductive layer with the third insulating film used as a mask to form stacked gate structures each having a control gate, second gate insulating film and floating gate;

removing part of the first insulating film which lies on the main surface of the semiconductor substrate

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and is disposed between the stacked gate structures to expose the main surface of the semiconductor substrate and leave another part of the first insulating film which lies under the stacked gate structures, each part of the first insulating film which is left behind under the stacked gate structures acting as a first gate insulating film;

doping impurity into the main surface of the semiconductor substrate with the stacked gate structures used as a mask to form source and drain regions; and

making nitrogen concentration of part of the first gate insulating film which lies on the impurity diffused layers lower than nitrogen concentration of part of the first gate insulating film which lies under the stacked gate structures by oxidizing the stacked gate structures and impurity diffused layers at temperatures not lower than 950°C.

21. The semiconductor device manufacturing method according to claim 20, wherein said step of lowering the nitrogen concentration of part of the gate insulating film which lies on the impurity diffused layers is effected by use of a wet oxidation method.

22. A semiconductor device manufacturing method comprising the steps of:

forming a first insulating film in an oxynitride form on a main surface of a semiconductor substrate;

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Fig 2

forming a first conductive layer on the first insulating film;

forming a second insulating film on the first conductive layer;

5 forming a second conductive layer on the second insulating film;

forming a third insulating film on the second conductive layer;

10 patterning the third insulating film to form a mask;

etching the second conductive layer, second insulating film and first conductive layer with the third insulating film used as a mask to form stacked gate structures each having a control gate, second gate  
15 insulating film and floating gate;

removing part of the first insulating film which lies on the main surface of the semiconductor substrate and is disposed between the stacked gate structures to expose the main surface of the semiconductor substrate  
20 and leave another part of the first insulating film under the stacked gate structures, each part of the first insulating film which is left behind under the stacked gate structures acting as a first gate insulating film;

25 forming a post oxidation film on side walls and upper surfaces of the stacked gate structures and the exposed main surface of the silicon substrate;

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oxynitrifying the post oxidation film; and  
doping impurity into the main surface of the  
semiconductor substrate with the stacked gate  
structures used as a mask to form source and drain  
regions.

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